# Short Term Assessment of Sediment Transport and System Dynamics of the Napatree Point Lagoon, Watch Hill, RI

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**Abstract**
The Napatree Lagoon is located at the west end of the Napatree Point Conservation Area in Watch Hill, RI, and is an important conservation area for various shorebird species and fish and invertebrates such as the horseshoe crab. Understanding the geomorphology of the lagoon system is vital to ensuring the overall health of this unique ecosystem. Tidal current velocities and bedform surveys were collected at various locations in the lagoon to capture a complete tidal cycle between June and August of 2019 and plotted on a composite curve to look at the potential sediment transport capabilities of the ebb and flood currents. The bedform survey data and the elevation data were both imported into ArcGIS for spatial analysis. Continuous elevation data of the tidal delta and channel cross sections were also collected in both July of 2019 and January 2020 using RTK-GPS. Elevation data from January 2020 was compared to April 2018 U.S. Army Corps of Engineers LIDAR data. The analysis shows the area exhibited net deposition of 440m$^3$ of sediment over 15-months. Current velocity curves support this, showing tidal currents within the inlet are asymmetrical, and can potentially transport more sediment during the flood than during the ebb. The cross-section of the inlet (January 2020) was calculated to be 3.2m$^2$, smaller than both the 2018 measurement (5m$^2$), and the calculated channel size based on the tidal prism of the lagoon (5.3 m$^2$). This suggest the lagoon inlet could close, separating it from Little Narraganset Bay and bears further monitoring.

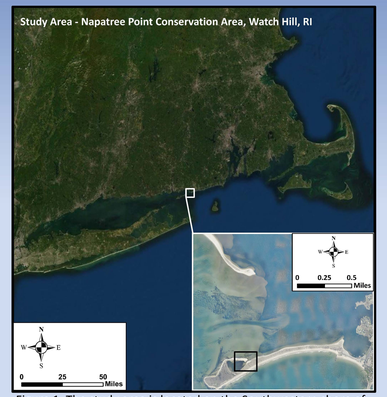


Figure 1. The study area is located on the Southwestern shore of RI, at the western end of the Napatree Conservation Area spit.

Figure 2. Field work: using RTK-GPS to measure channel cross sections and create bathymetric model of the flood-tidal delta.

Figure 3. Field work: Measuring channel current velocities.

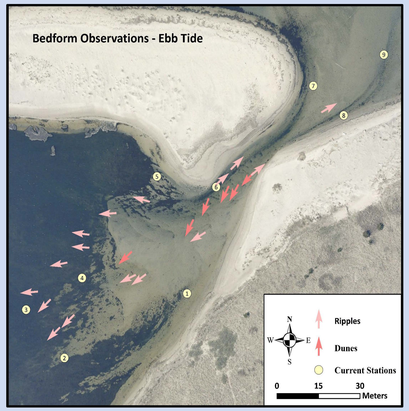


Figure 4. Sedimentary bedform observations, post-ebb tide. Arrows indicate direction of motion. Ripples are ebb oriented in the channel and dunes remained flood oriented.

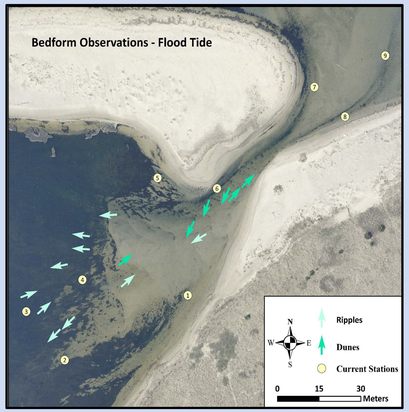


Figure 5. Sedimentary bedform observations, post-flood tide. Arrows indicate direction of motion. Note that a majority of the bedforms are flood oriented.

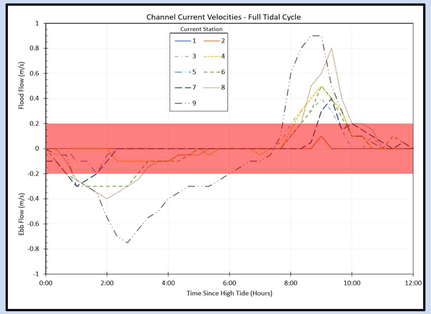


Figure 6. Channel current velocity observations throughout a full twelve-hour tidal cycle. Negative values indicate ebb flow and positive values, flood. Locations of corresponding stations are shown in figures 4 and 5. Sediment transport of the medium grain sand is initiated with flow >0.2 m/s, therefore, flow within the red shaded area is assumed to be insufficient to transport sediment. Flood current velocities are observed to have higher peak flow, yet for a shorter duration than the ebb current.

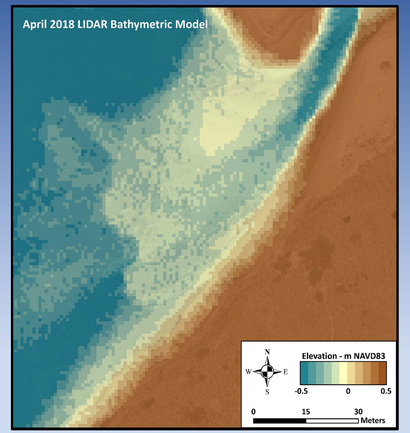


Figure 7. Bathymetric model of Napatree Point Lagoon, utilizing Army Corps of Engineer's 2018 LIDAR data, processed utilizing natural neighbor interpolation in ESRI ArcMap's Spatial Analyst. Elevation is measured in meters relative NAVD 1983.

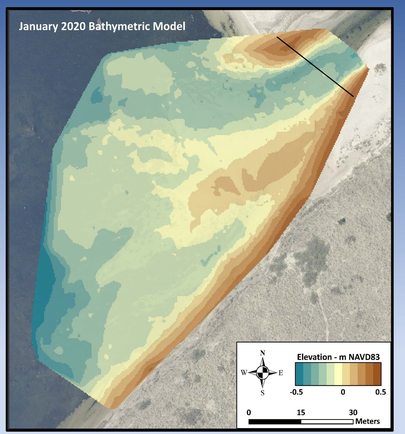


Figure 8. Bathymetric model of Napatree Point Lagoon, flood tidal delta, utilizing January 2020 RTK-GPS data, processed utilizing natural neighbor interpolation in ESRI ArcMap's Spatial Analyst. Elevation is measured in meters relative NAVD 1983.

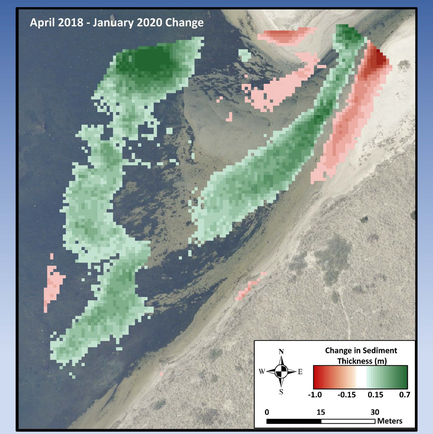


Figure 9. Depositional-Erosional model based on change in sediment thickness, in meters, from April 2018 to January 2020. ESRI ArcMap's Raster Calculator was utilized to create this model. Red indicates erosion and green indicates deposition. Deposition/erosion less than 0.15 (within uncertainty) is not shown..

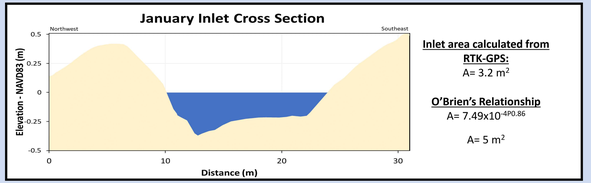


Figure 10. Cross sectional profile of the Napatree lagoon inlet. Location of cross-section is indicated by a black line in Figure 8. O'Brien's relationship was used to calculate the predicted inlet size based on the lagoon's tidal prism, P (29,000 m$^2$) (Augenstein et al., 2019).

Table 1. Calculated areas and volumes of flood-tidal delta sediment transport.

| | Deposition | Erosion | Net Change |
|---|---|---|---|
| | Volume (m$^3$) | Volume (m$^3$) | Volume (m$^3$) |
| April 2018 - January 2020 | 729 | -285 | 444 |

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**Bedform Observations:** Ripples and dunes are abundant throughout the flood tidal delta and various channels. The ripples and dunes are predominantly flood oriented when observed at both ends of the tidal cycle. Some ripples and dunes were observed to have flipped direction between ebb and flood orientation; however the orientation remains flood dominant throughout all observations. This suggests that flood currents dominate sediment transport in this system.

**Current Velocity Observations:** Current velocity measurements were taken every 15 minutes to capture data throughout a full tidal cycle. Current velocity was measured from 9 locations throughout the flood tidal delta and through the inlet channel. Flow velocity of 0.2 m/s was determined to be the minimum flow required to transport the medium grained sand found in this system. During the ebb current, the flow velocities observed were smaller in magnitude and longer in duration than those of the flood current. More sediment transport capabilities were observed at each of the nine stations during the flood current, suggesting that the system is dominated by deposition.

**Flood-tidal Delta Sedimentation:** The sedimentation observed through the bathymetric models from April 2018-January 2020, indicate a net depositional system. Throughout this time period, 729 m$^3$ of sediment was deposited in the flood tidal delta and 285 m$^3$ was eroded from the system, for a net deposition of 444 m$^3$. The tidal delta has also undergone drastic changes in morphology. From 2018-2020, the inlet channel has shifted from the south end of the inlet to the northern end. Figure 7 reveals the extent of the deposition and erosion observed over this period. The net deposition observed reveals the potential for the lagoon to fill with sediment and eventually close off from the bay.

**Channel:** The predicted inlet size of 5 m$^2$, calculated using O'Brien's equation, and the measured inlet size of 5 m$^2$ by Augenstein et al., 2019 are larger than the cross-sectional area measured during the January 2020 survey. The inlet area in January 2020, was calculated to be 3.2 m$^2$. This decrease suggests that the lagoon inlet could close, separating the lagoon from Little Narraganset Bay and bears additional monitoring.